X-ray Magnetic Linear Dichroism of Fe-Ni Alloys on Cu(111)

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INTRODUCTION

We are studying layer-by-layer synthesis of ultra-thin metal films by controlling at the monolayer level the composition and structure of these films, including the interfacial region. We have prepared Fe_xNi_{1-x} multilayers using simultaneous evaporation of pure Fe and Ni on Cu(111) in order to better understand the Giant Magnetoresistance (GMR) effect in FeNi/Cu systems that are relevant to magnetic disk drive heads. Using Undulator Beamline 7.0 and the Spin Spectroscopy Facility (7.0.1.2) at the ALS, we have measured X-ray Magnetic Linear Dichroism (XMLD) signals for twenty three different thin Fe-Ni alloys films on Cu(111) for different thicknesses and with Fe concentration ranging from 9% to 84%. X-ray Photoelectron Spectroscopy (XPS) with 1250 eV photon energy was utilized to determine both thickness and elemental composition. The Fe3p and Ni3p lines were measured for magnetization up and down, and the difference is the XMLD signal. Our XMLD spectra clearly indicate that samples of specific thicknesses and Fe concentrations are ferromagnetic. XMLD has previously been used to characterize Fe_xNi_{1-x} alloy fcc multilayers on Cu(100)[1].

RESULTS

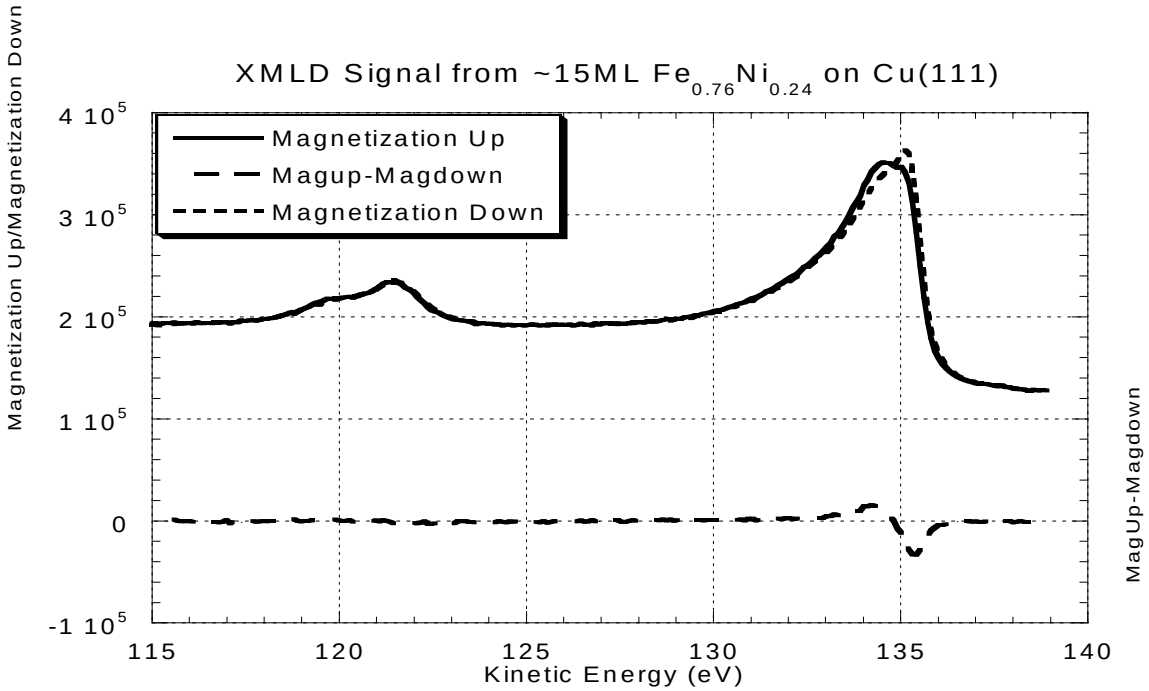

Figure 1. XMLD date from Fe-Ni thin film, 15ML thick, on Cu(111). Top of figures shows the signal for both magnetizations up and down. Bottom of figure shows difference, which is proportional to the dichroism.

Fig. 1 shows the XMLD effect for Fe concentration of 0.76 and thickness of 14ML. The upper panel clearly shows that the XPS data are different depending on the orientation of the applied field relative to the sample. The lower panel shows the difference between the two spectra in the upper panel and exhibits the dichroism effect. We have also measured the dichroism signal from both the Fe and the Ni peaks, which allows for calculation of the asymmetry.

The asymmetry is defined as, $\frac{\text{MagUp - MagDown}}{\text{MagUp + MagDown}}$, as measured from the XMLD signal.

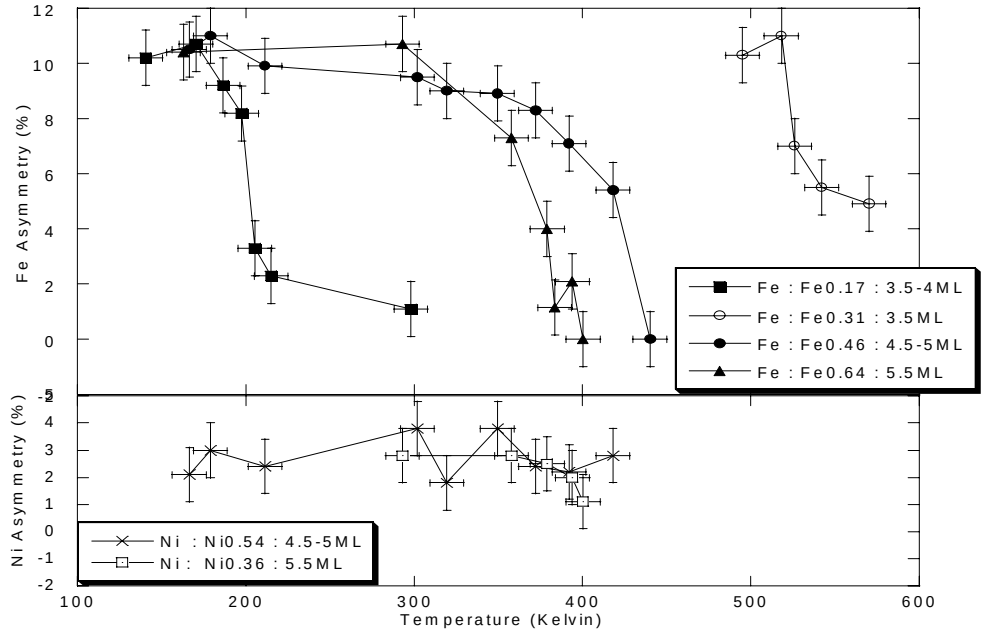

Figure 2. Fe and Ni asymmetry as a function of temperature for four Fe concentrations with film thicknesses near 5ML**.**

Figure 2 shows the asymmetry as a function of temperature for films with four different Fe concentrations and two different Ni concentrations, all ~5ML thick. The Fe data appear to fit the predictions from mean field theory, and preliminary attempts at mean field fits have had limited success. With increasing Fe concentration, the Curie temperature, where the asymmetry disappears, increases until x≈0.6, (near the Invar transition point) and then decreases.

Fig. 3 shows the total weighted asymmetry, $A_{T,}$ which is computed by performing a weighted sum of elemental asymmetries to obtain[2],

$$A_T=xA_{Fe}+(1-x)A_{Ni,},$$

with A_{Fe} and A_{Ni} being the asymmetries measured from the XMLD spectra for Fe and Ni respectively. Note that A_T also shows a magnetic instability near x=0.65. The data also support similar results by Schumann *et al* for FeNi on Cu(001). We observe that as the Fe concentration increases, we observe A_T to have an initial value of about 2%, which then monotonically increases to a maximum of about 8.5% at the Invar transition concentration. For Fe concentrations greater than x=0.65, the weighted asymmetry is quenched. As the system goes through the quenching transition, it goes from a highly aligned, high spin state to an admixture

that includes a low spin state for the Fe. For Fe on CuAu(100) multilayers, Keavney *et al*[3] also found high Fe asymmetry for Fe concentration less than or equal to 60%.

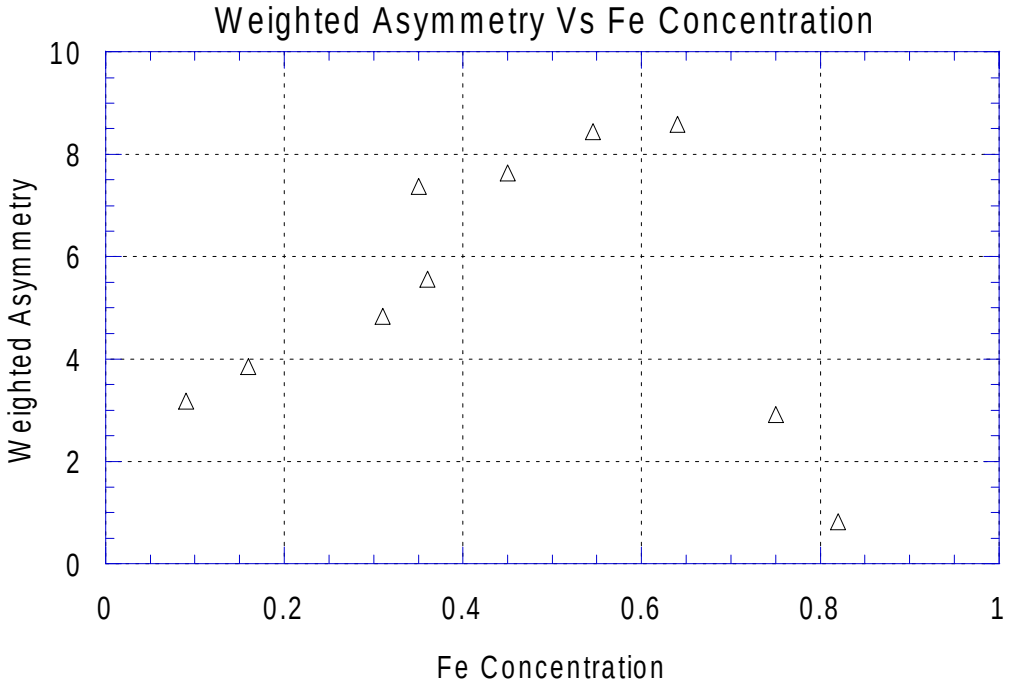

Fig. 3 Total weighted asymmetry of FeNi alloy as a function of Fe concentration for film thicknesses near 5 ML

Work is progress to compare the data in Figure 3 with previously published SQUID measurements[4] for FeNi films on Cu(111) in order to perform an absolute calibration of the XMLD signal.

REFERENCES

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